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Forest Insect And Disease Management

Resurrection Creek Spruce Beetle Infestation:

A Three Year Interim Report

January 1979

U.S. Department of Agriculture
State and Private Forestry

Forest Service
Alaska Region

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INTRODUCTION:

Alaska white spruce (Picea glauca [Moench] Voss) forests are subject to mortality from a variety of causes: wind, disease, fire and insect outbreaks. Of all the insects, the spruce beetle (Dendroctonus rufipennis Kby.), is the most devastating.

Periodically, spruce beetle infestations increase rapidly causing widespread damage. In the early 1960's spruce beetle infestations on the Kenai Peninsula covered approximately 105,220 hectares, with losses estimated at two hundred million cubic feet. In 1972, an outbreak was reported from Tyonek on the west side of Cook Inlet. Three years later, this outbreak extended over 115,000 hectares.

In 1974 and 1975, a few hundred acres of scattered white spruce blowdown occurred along Resurrection Creek near Caribou Creek, approximately 17 kilometers from Hope, Alaska. Endemic spruce beetle populations rapidly infested this highly susceptible brood material. Populations increased and began to attack standing white spruce in the immediate area. A major infestation was beginning.

The Resurrection Creek infestation extended over 3,238 hecatares in 1976, mostly around Caribou Creek. By 1978, the infestation covered almost 6,070 hectares.

Due to the extent and accessibility of this infestation it was decided that permanent plots should be established in order to determine the impact of spruce beetles on white spruce forests.

OBJECTIVES:

The principal objective of this study is an indepth investigation concerning the impact of spruce beetle depredation. The following objectives are emphasized:

1. Determine the various mortality agents associated with a spruce beetle infestation.

2. Determine spruce beetle attack patterns, kill and pitch-outs as related to host diameter and year for five years.

3. Determine the annual white spruce mortality caused by spruce beetles.

4. Determine site characteristics (e.g. soil type, aspect, elevation) associated with host susceptibility, attack density and host mortality.

The following discussion is presented as a three year interim report. Upon completion of this study in 1980, a final report will be prepared. Close coordination with the Institute of Northern

Forestry (Fairbanks) in various phases of this study will ensure that all objectives are met.

MATERIALS AND METHODS:

In October 1976, 30 one-fifth acre study plots were established in the Resurrection Creek drainage (Fig. 1). The plots were randomly located throughout the most intense portion of the infestation. Each of the circular plots (radius = 52.7') was marked at the center by an orange five-foot stake. All live trees greater than 1 inch DBH (except alder) were tagged at breast height. In February 1977, all dead spruce on the plots were also tagged. The data which was collected from individual trees included species, DBH, beetle activity, damage from other causes and mortality. On each plot, core samples were taken from co-dominant and dominant trees. Likewise, tree heights were recorded on 14 of the 30 plots. Ground cover and various site characteristics were also noted.

Data collection was undertaken on an annual basis each October. The first monitoring occurred during the October 1976 plot establishment. Since then data has been collected in 1977 1/ and 1978. This study will be continued through the 1980 spruce beetle flight season.

RESULTS AND DISCUSSION:

Stand Composition

The forest along the Resurrection Creek drainage is primarily composed of white spruce, with paper birch (Betula papyrifera Marsh.), black cottonwood (Populus trichocarpa Torr. and Gray) and mountain hemlock (Tsuga mertensiana [Bong.] Carr.) comprising less than 10 percent of the stand (Fig. 2). The diameter distribution of the spruce is given in Fig. 3. 48 percent of the spruce has a diameter of 8.9" or less.

Thirty of the cored trees were used for age and growth determination. These cores hit "dead center", giving the most accurate age determinations. The average age of these dominant and co-dominant trees was 148 years. Inside bark diameter averaged 10.78 inches. Average growth was 0.08" per year, with a 0.05" per year average growth for the last 10 years.

1/ 1977-October data was actually collected in April 1978. For practical purposes, it is discussed as 1977 data.

Ground cover on plots 101 - 107 (East Creek) is primarily composed of heavy mosses, Salix, lichens, Vaccinium spp., Cornus spp., Epilobium spp., Rosa spp., grasses, heather and Delphinium Spp. However, ground cover on plots 108 - 130 (Caribou Creek) was much more diverse. In addition to the species listed above, Equisetum spp., Rubus Spp., Sambucus spp., Ledum spp., Heracleum spp., Linnaea spp., Sanguisorba spp. and Oplopanax spp. were encountered.

Pre-Outbreak Condition:

As previously stated, all dead spruce occurring on the plots were recorded in 1976. It was easy to determine if these dead trees were beetle killed. By combining the dead spruce with all living spruce on each plot at the beginning of the study, we could reconstruct the pre-outbreak condition of the stand in terms of mortality. However, we did not try to date the pre-1976 dead spruce. Beetle killed timber in Alaska can remain standing for 50 years or more. Accordingly, pre-outbreak mortality is not expressed in terms of years. However, as seen in Fig. 4, there has been little (6%) spruce beetle mortality occurring in the Resurrection Creek drainage before 1976. Likewise, porcupine caused mortality and unknown causes accounted for even less, 1% and 2% respectively. Spruce beetle-caused mortality before 1976 was probably due to low endemic beetle populations.

OUTBREAK CONDITIONS 1976-1978

It is apparent from Fig. 5 and Table 1 that the Resurrection Creek spruce beetle infestation is static-to-declining. Even though 80 percent or more of the spruce has remained non-infested for three years, this is more of a reflection of stand composition than beetle impact. Forty-eight percent of the trees are under 9" d.b.h., a size normally considered resistant to spruce beetle attack. However, the number of spruce beetle killed timber significantly increased in 1977, but remained virtually the same in 1978. Pitchouts significantly increased in 1978 over the two previous years. New infestations, on the other hand, have significantly decreased in 1977 and 1978.

A. Number of Beetle Killed Trees:

For the most part the number of beetle killed trees as related to diameter class has significantly increased each year (Table 2). This is especially true for the 5", 11" and 15" diameter classes. Likewise, the susceptibility to beetle kill of a diameter class(s) has significantly changed from year to year (Table 3). In 1976 the 11" class had the most kills. Higher mortality was found in the larger diameter classes in 1977 changing to the smaller diameter classes in 1978. Trees noted as spruce beetle-killed in 1977 were actually killed in 1976. One year was allowed for color change or fading, a positive indication of mortality (Fig. 8).

B. Number of New Infestations:

The number of new infestations was significantly greater in 1976 and 1978 than in 1977. However, this is a reflection of the spruce beetle life cycle showing a stable population (e.g. 1978 new infestations are not significantly different than 1976 new infestations.) Emerging adults from 1976 new infestations are re-infesting spruce in 1978 (Fig. 6).

There has been a yearly change in diameter classes with the highest new infestations (Table 3). In 1976 new infestations were highest in the 15" and 17" diameter class. However, in 1978, more new infestations were apparent in the smaller diameter classes. This is probably a result of a reduction in susceptible host material; large diameter classes are preferred over smaller ones.

C. Number of Pitch-Outs:

Pitch-outs are a result of an unsuccessful beetle attack. The causes of pitch-outs can result from: (1) numbers of attacking beetles are too small to overcome host resistance, or (2) host is highly resistant (smaller diameter trees are in this category).

The number of pitch-outs has significantly increased over the years (Fig. 7, Table 1, 2). The most notable increases occurred in the 9" through 13" diameter classes. Likewise, the distribution of pitch-outs as related to diameter class(s) has changed on a yearly basis (Table 3). Significantly more diameter classes had pitch-outs in 1978 than in 1977 or 1976.

D. Total Mortality:

Total mortality, which includes spruce beetle kills, disease, porcupine related kills, windthrow, and unknown causes, was 163 trees over three years. However, only 13 percent (13 trees) was due to causes other than spruce beetles. It appears that the spruce beetle is the most significant white spruce mortality agent in the Resurrection Creek Drainage.

Volume Loss:

All spruce 9" d.b.h. and above, have been measured for height on 14 plots. These plots were among the 22 located around Caribou Creek, the area of heaviest beetle activity. Volume estimates were derived from R-10 volume tables for white spruce in Alaska in board feet, Scribner.

Volume was estimated to be 2989 cubic feet per acre. Volume loss

that can be attributed to spruce beetles amounted to 819 cubic feet per acre over a three year period. This is 27 percent of the total volume per acre. The heaviest bark beetle activity is occurring on 3480 hectares. The estimated 3 year volume loss for this area would be 7,046,021 cubic feet, or enough timber to build 3500 small 3-bedroom homes.

One percent of the volume of spruce beetle killed timber occurred in 1976 (8ft^3/acre), 61 percent in 1977 (500 ft^3/acre), and 38 percent (311 ft^3/acre) in 1978.

The volume of timber killed by spruce beetles during pre-outbreak conditions was estimated to be 364 ft^3/acre. However, it is not known whether this volume was lost over a time period of ten years, 20 years, or longer. Nevertheless, this pre-outbreak volume loss is only 44 percent of the volume lost during the 1976-1978 period.

Future Trends and Impact of Spruce Beetle Infestations:

It appears that along the Resurrection Creek, from Caribou Creek to East Creek, the spruce beetle infestation is static-to-declining. This is based on the weighted percent of new infestations depicted in Fig. 5. However, due to the significant increase in pitch-outs (Fig.5), the population may decline in a few years in the vicinity of the original infestation. This decline probably is a result of a reduction in susceptible host material along the creek bottoms. The larger diameter, susceptible spruce have been attacked and killed in the first few years. Emerging beetles are forced to attack the smaller diameter, more resistant spruce or fly elsewhere. In fact, 1978 aerial surveys of the infestation detected more intense spruce beetle activity higher up the slopes, up to tree line. Increased mortality can be expected in these areas for a few years.

Apart from the volume loss, the spruce beetle will probably have a minimal effect on forest composition. Figs. 3 and 5 depict the large quantity of non-infested trees (smaller diameter classes) which will contribute to the future growing stock.

A final evaluation of the impact of the Resurrection Creek infestation will be undertaken when the study is completed in the Fall of 1980. At this time, a more accurate picture will be presented with respect to volume lost, site characteristics as related to spruce beetle activity, effects on forest stocking, wildlife habitat, forest fire risk and recreation use.

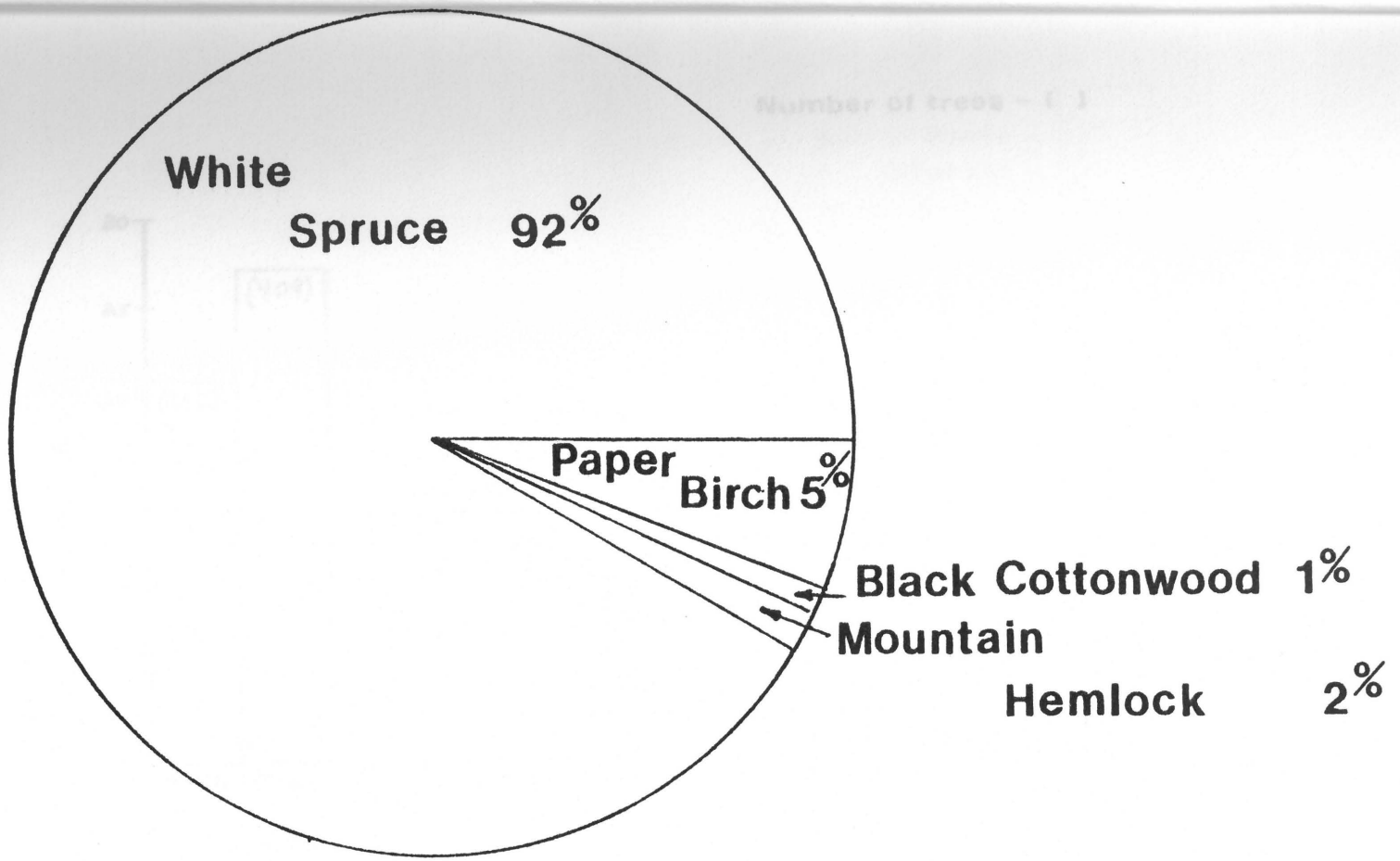


Fig. 2 Resurrection Cr. Stand Composition

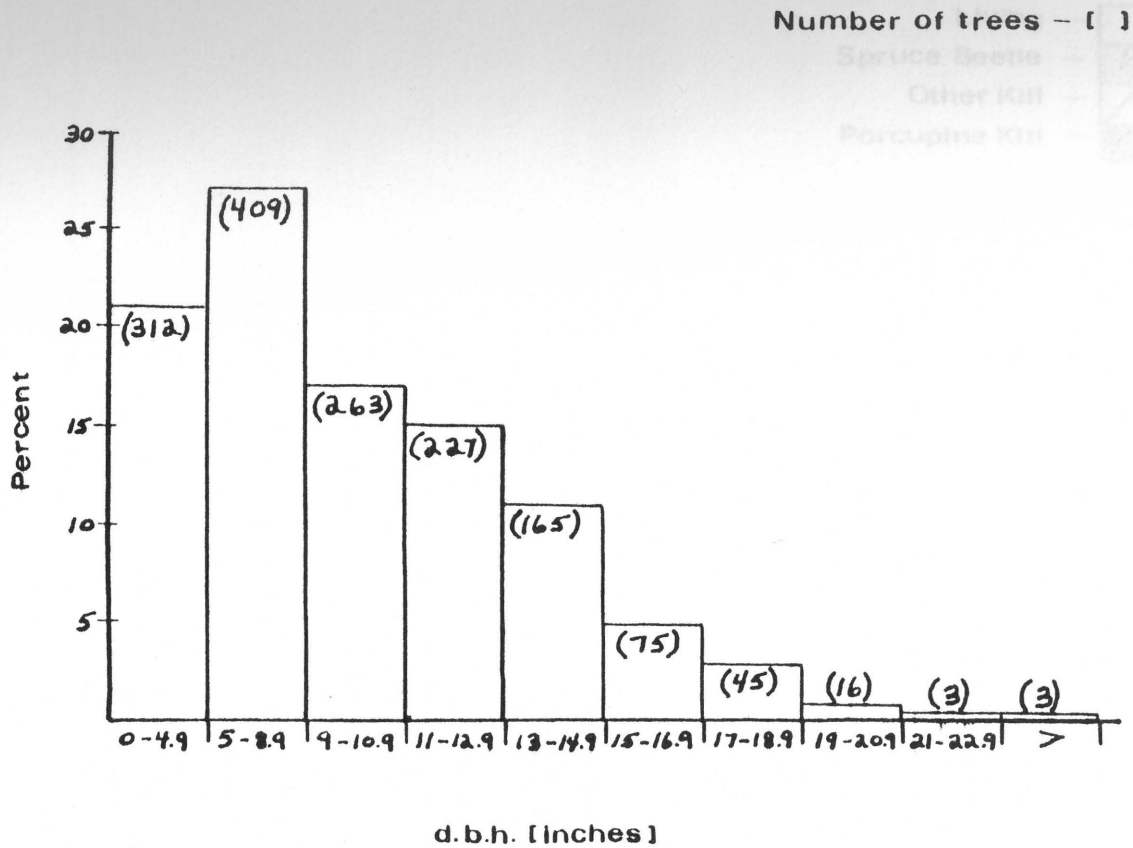


Fig. 3 Distribution of white spruce by diameter

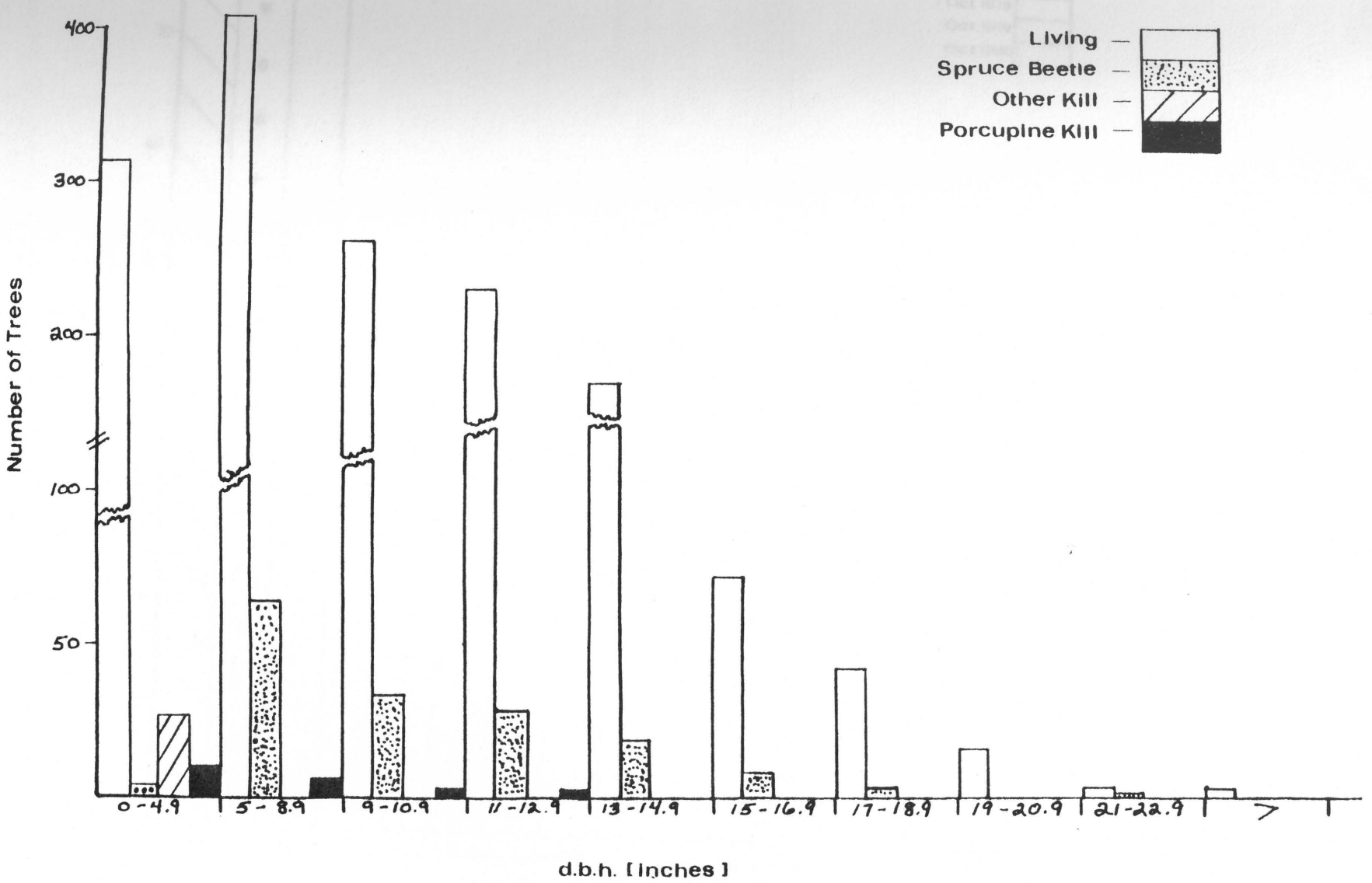


Fig.4 Pre-outbreak stand condition as related to diameter

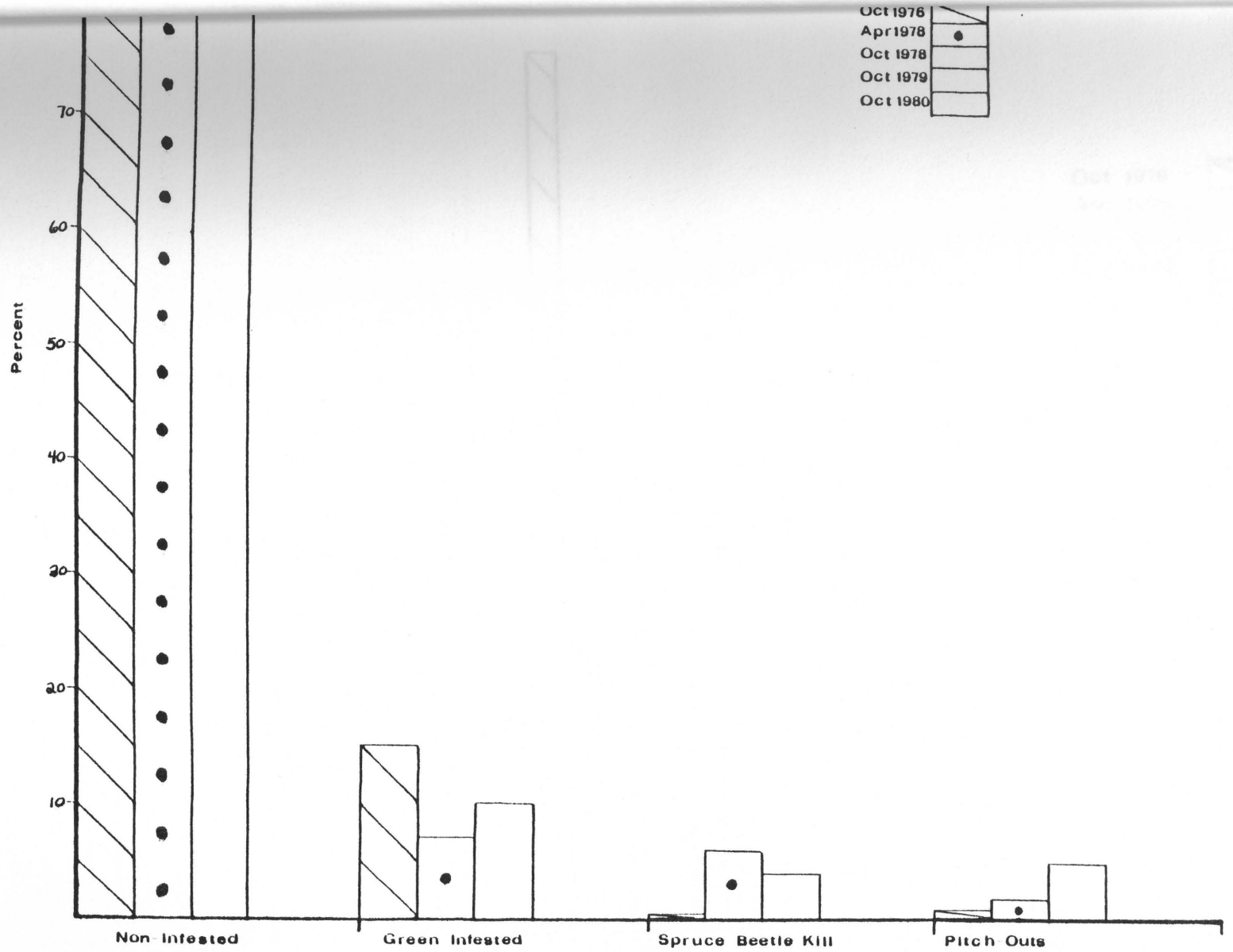


Fig. 5 Stand condition as related to beetle activity

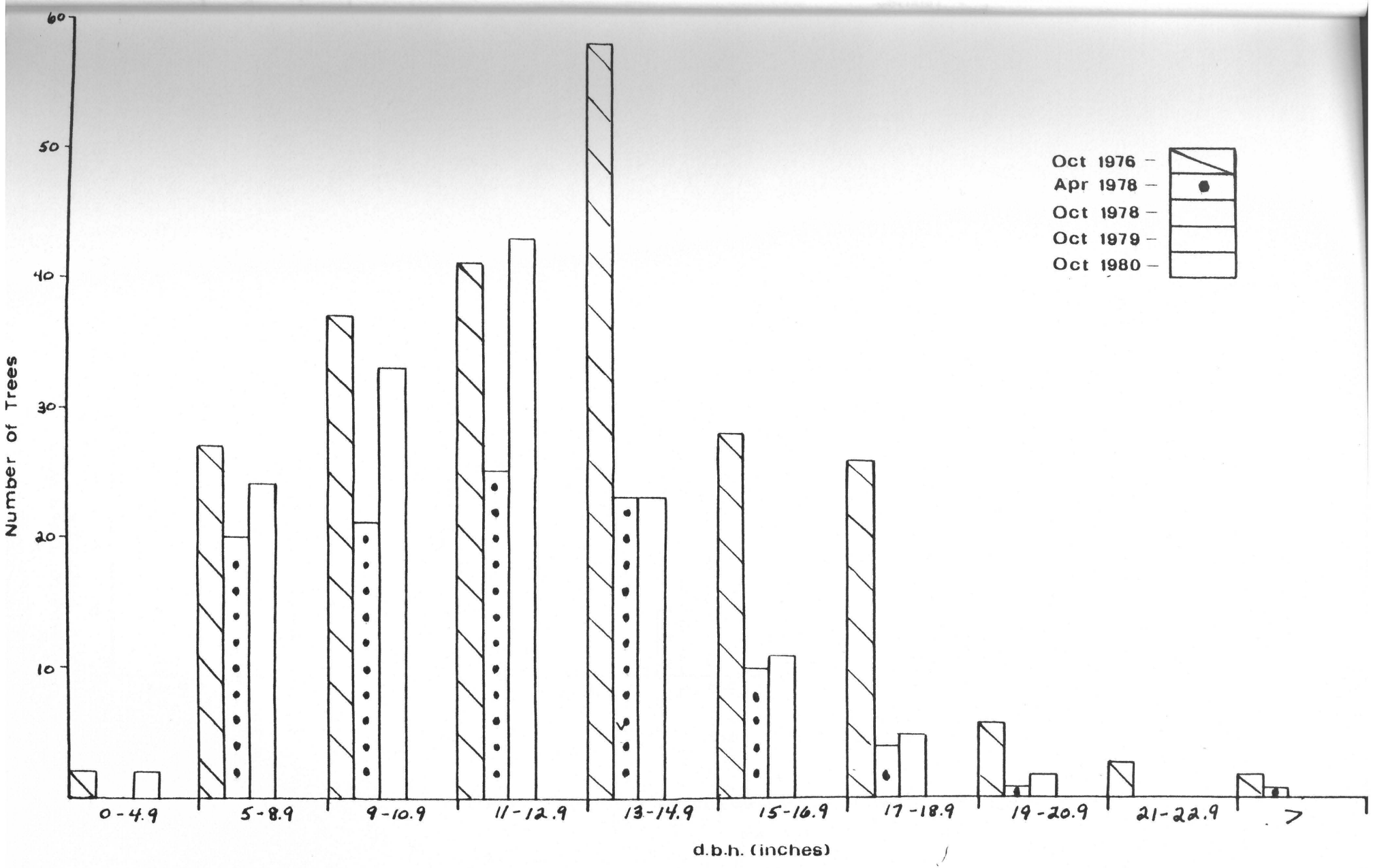


Fig 6 Number of green infested white spruce as related to diameter

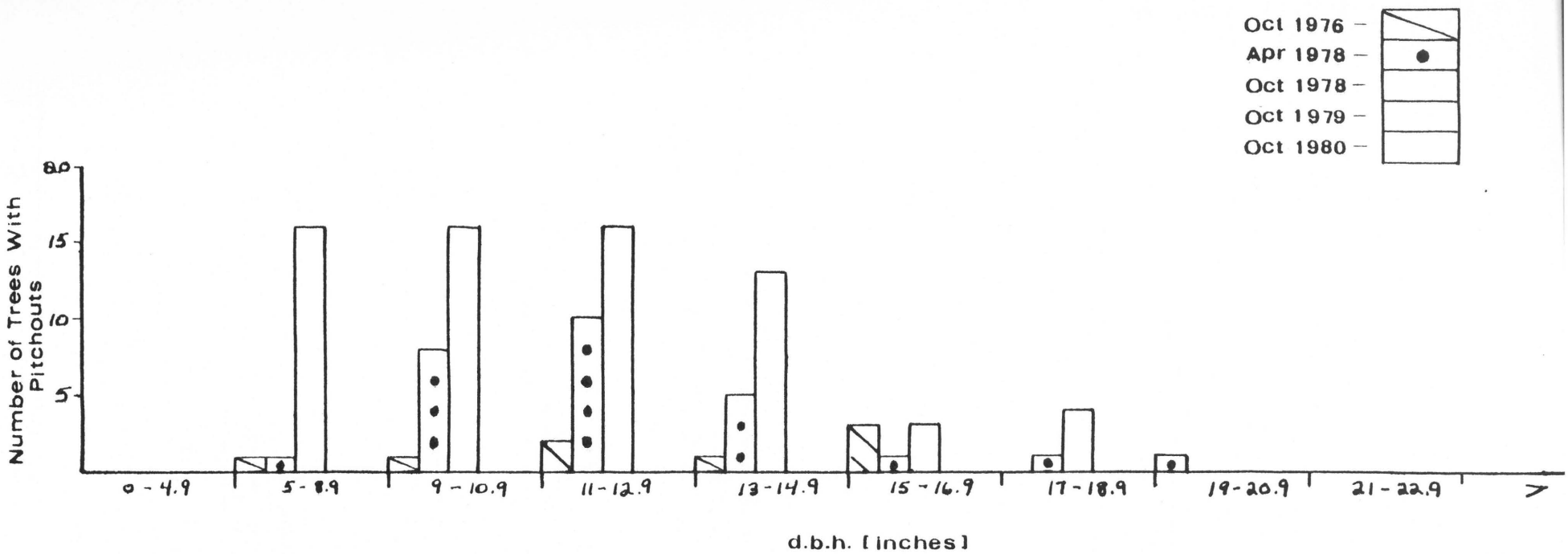


Fig.7 Number of "pitch-out" white spruce as related to diameter

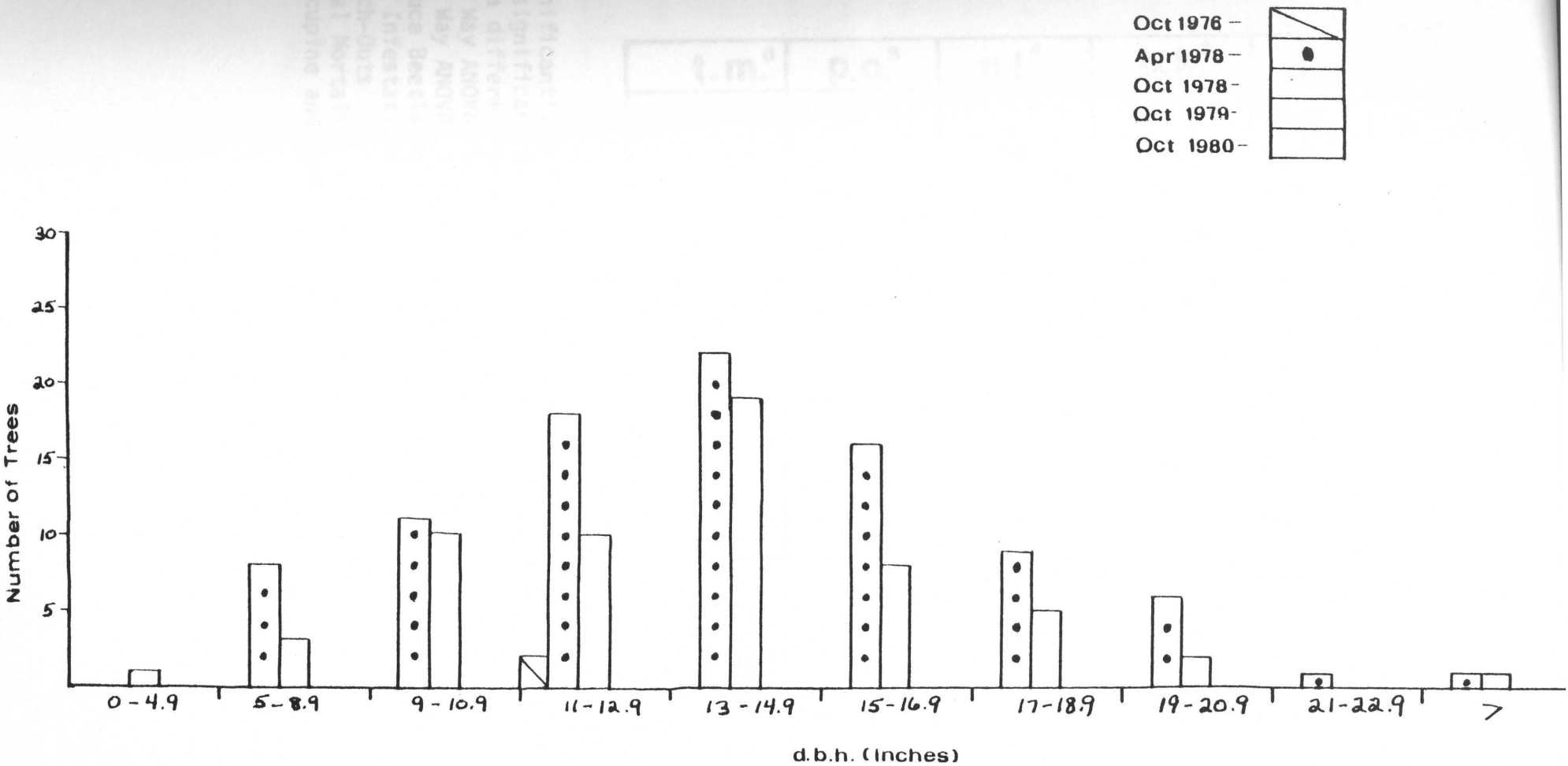


Fig.8 Number of beetle killed white spruce as related to diameter

Table 1. Statistical Summary of Four Bark Beetle Related Variables as Related to Year.

	1976	1977	1978
b.k.[3]		X_2^*	X_2^*
n.l.[4]	X_2		
p.o.[5]			X_1
t.m.[6]		X_2^*	X_2^*

X = Significantly different @ .05
* = No significant difference between same category which is "X'd" in a different year.
1 = One Way ANOVA, LSD @ .05
2 = One Way ANOVA, SCHEFFE @ .05
3 = Spruce Beetle Kills
4 = New Infestations
5 = Pitch-Outs
6 = Total Mortality = Spruce Beetle Kill, Disease, Windthrow, Porcupine and Unknown.

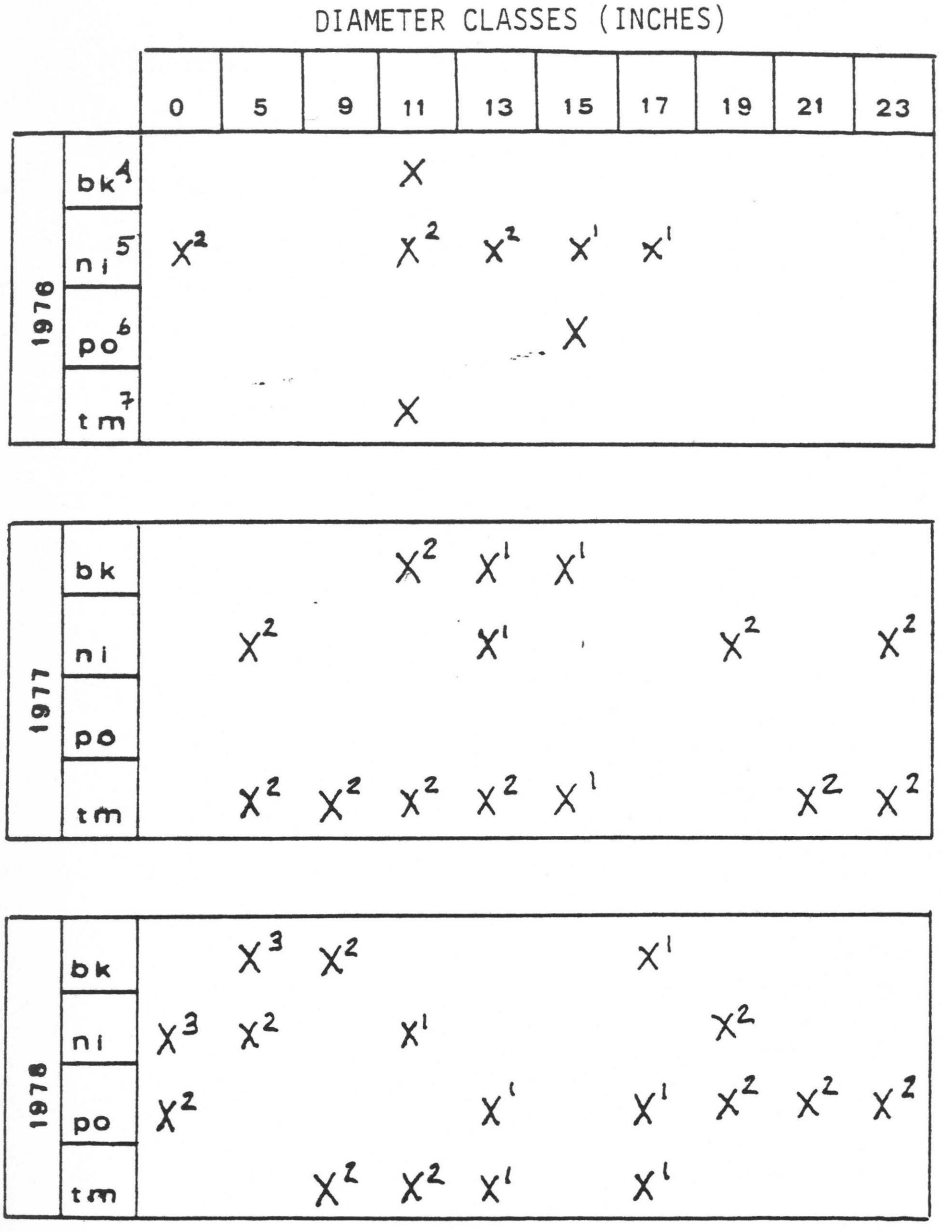
Table 2. Statistical Summary of Ten Diameter Classes and Four Variables as Related to Year.

	1976				1977				1978			
dc[3]	b.k.[4]	n.i.[5]	p.o.[6]	t.m.[7]	b.k.	n.i.	p.o.	t.m.	b.k.	n.i.	p.o.	t.m
0												
5	X_1			X_1	X_1			X_1	X_1		X_2	X_1
9		X_1^*	X_1		X_1^*		X_1	X_2^*	X_1^*	X_1^*	X_1	X_2^*
11	X_1	X_1^*	X_1	X_1	X_1		X_1	X_1	X_1	X_1^*	X_1	X_1
13		X_2^*	X_1		X_2^*		X_1	X_2^*	X_2^*		X_1	X_2^*
15	X_1	X_2		X_1	X_1			X_1	X_1			X_1
17		X_2			X_1^*			X_1^*	X_1^*			X_1^*
19		X_1										
21												
23												

DIAMETER CLASSES

X = Significantly different @ .05
1 = One Way ANOVA, LSD @ .05
2 = One Way ANOVA, TUKEY @ .05
* = No sign. diff. between same category which is "X'd" in a different year.
3 = Lower limit of diameter class in inches
4 = Spruce Beetle Kills
5 = New Infestations
6 = Pitch-outs
7 = Total Mortality = Spruce Beetle Kill, Disease, Windthrow, Porcupine and Unknown.

Table 3. Statistical Summary* of Yearly Changes in Four Variables as Related to Diameter Class in Inches



X = Significantly different @ .05
* = One Way ANOVA, LSD @ 0.05
1 = Largest Sign. Diff. - 2 or more "1's" are not sign. diff. from one another.
2 = Second Largest Sign. Diff. - 2 or more "2's" are not sign. diff. from one another.
3 = Third Largest Sign. Diff. - 2 or more "3's" are not sign. diff. from one another.
4 = Spruce Beetle Kills
5 = New Infestations
6 = Pitch-Outs
7 = Total Mortality = Spruce Beetle Kill, Disease, Windthrow, Porcupine and Unknown.

APPENDIX A: Summary of 1976 Resurrection Creek Spruce Beetle Impact Data.

APPENDIX B: Summary of 1977 (=April 1978) Resurrection Creek Spruce Beetle Impact Data.

APPENDIX C: Summary of 1978 Resurrection Creek Spruce Beetle Impact Data.

APPENDIX A

D.B.H.	0-4.9	5-8.9	9-10.9	11-12.9	13-14.9	15-16.9	17-18.9	19-20.9	21-22.9	23-	TOTAL
1. NON-INFESTED**	310	379	224	185	111	44	16	11	0	1	1281
2. GREEN INFESTED	2	27	37	41	58	28	26	6	3	2	230
3. SPRUCE BEETLE KILL				2							2
4. PITCH-OUTS		1	1	2	1	3					8
5. WINDTHROW											
6. PORCUPINE KILLED			1								1
7. DISEASED		1	1								2
8. BROKEN TOP	1	5	3								9
9. UNKNOWN CAUSED MORTALITY											
10. LIVE TREES WITH PORCUPINE DAMAGE		2	1								3
TOTALS	312	408	263	228	169	72	42	17	3	3	1517

** = Includes totals from catagories 1, 4, 7, 8, 10

APPENDIX B

D.B.H.	0-4.9	5-8.9	9-10.9	11-12.9	13-14.9	15-16.9	17-18.9	19-20.9	21-22.9	23-	TOTAL
1. NON-INFESTED**	312	372	228	183	119	46	29	8	2	1	1299
2. GREEN INFESTED		20	21	25	23	10	4	1		1	105
3. SPRUCE BEETLE KILL		8	11	18	22	16	9	6	1	1	92
4. PITCH-OUTS		1	8	10	5	1	1	1			27
5. WINDTHROW					2	2	1				5
6. PORCUPINE KILLED	1	1									2
7. DISEASED	1	2									3
8. BROKEN TOP	1	5	3								9
9. UNKNOWN CAUSED MORTALITY		3		1		1	1	1			7
10. LIVE TREES WITH PORCUPINE DAMAGE		2	1								3
TOTALS*	313	406	261	227	166	75	44	16	3	3	1514

* = Adjusted for previous year's mortality
** = Includes totals from catagories 1, 4, 7, 8, 10

D.B.H.	0-4.9	5-8.9	9-10.9	11-12.9	13-14.9	15-16.9	17-18.9	19-20.9	21-22.9	23-	TOTAL
1. NON-INFESTED**	308	368	218	153	93	34	23	5	2	0	1204
2. GREEN INFESTED	2	24	33	43	23	11	5	2			143
3. SPRUCE BEETLE KILL	1	3	10	10	19	8	5	2		1	59
4. PITCH-OUTS		16	16	16	13	3	4				68
5. WINDTHROW		1			6	2	1			1	11
6. PORCUPINE KILLED		1									1
7. DISEASED	1	5	2	2	2						12
8. BROKEN TOP	1	12	4		1						18
9. UNKNOWN CAUSED MORTALITY			1			1					2
10. LIVE TREES WITH PORCUPINE DAMAGE	2	6	1		1						10
TOTALS*	311	397	262	206	141	56	34	9	2	3	1420

* = Adjusted for previous year's mortality
** = Includes totals from catagories 1,4,7,8,10